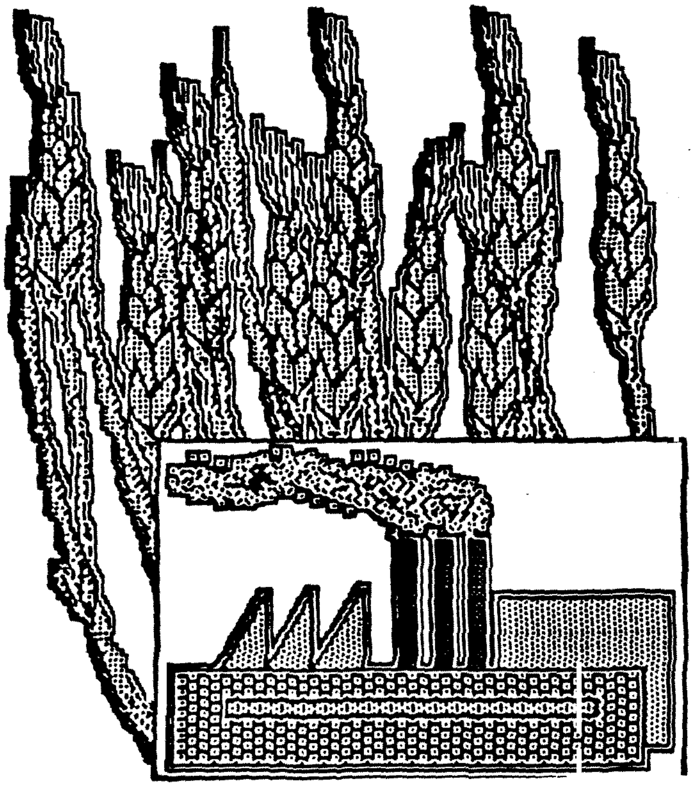
Southern Biomass Conference

July 26-28, 1988

A Joint Meeting of the
Southern Biomass Energy Research Group
and the Southern Forestry Biomass Working Group



Hosted by Auburn University
Auburn, Alabama 36849

POTENTIAL FOR SITE PRODUCTIVITY DECLINE FROM BIOMASS PRODUCTION ON SANDHILL SITES

Kenneth W. Outcalt
USDA Forest Service
Southeastern Forest Experiment Station
Olustee, Florida 32072

There has been considerable interest paid by forest industry and the U.S. Forest Service to the potential of Choctawhatchee sand pine (*Pinus clausa* var. *immuginata* D. B. Ward) for biomass production on sandhill sites in the Southeast. Sandhill soils are infertile because they consist largely of deposits of quartz sands, ranging from a few feet to more than 20 ft deep. Organic matter content is low because the climate promotes rapid oxidation. Because of the low levels of organic matter and clay colloids, cation exchange capacities, and thus nutrient retention of these soils, are low. Biomass harvesting, unlike conventional harvesting, often involves more complete removal of tree crops and shorter rotations which increases the level of nutrient removal. Thus, there is concern that site productivity will decline because of the greater nutrient drains from biomass production on sandhill sites.

Two management systems for biomass production are evaluated here for possible productivity declines due to nutrient removals. The first system is based on high-density plantings (6640 trees/ha) and a short (12 year) rotation. The second system is a mixed output one with 2470 trees/ha. Half of the trees would be harvested at age 10 for biomass and the rest would be carried to age 25 for conventional pulpwood production. The average diameter and height of sand pine at the appropriate ages and densities were inserted into biomass equations to give the weight of the various tree components. Needle weights were then multiplied by the percent N and P for sand pine needles and the weight of the other tree components by the percent N and P in loblolly pine to give an estimate of the amount of N and P per tree under the two different systems. Next, these numbers were multiplied by the number of trees to estimate the amounts of N and P per unit area in the various portions of sand pine stands. The potential removals under different management systems were calculated by adding the contents of nitrogen (N) and phosphorus (P) for the appropriate tree components together. Lastly, an evaluation of the potential for site decline from removals of nitrogen and phosphorus, the two nutrients most often limiting on sandhill sites, was made based on a comparison of this information to the nutrient inputs, outputs, reserves, and cycling rates.

Inputs are mainly from precipitation and dust. Total N inputs range from 1 to 2 kg/ha/yr in western locations to 13 kg/ha/yr on sites near major industrial centers, and averaging 5.6 kg/ha/yr in Florida. Phosphorus inputs are smaller but just as variable, ranging from 0.1 kg/ha/yr in Ontario to 1 kg/ha/yr in Florida.

Nutrients are removed from forest sites by water in either dissolved form or as sediments contained in runoff. Leaching typically removes only small amounts of elements from undisturbed forest systems. This is due to the internal conservative features of the forest. Although fair quantities of nutrients may be leached from the forest floor, most are removed before the groundwater has penetrated beyond rooting depth. It is also generally agreed that loss of nutrients by erosion and sediment removal are low in undisturbed forests. Data from various studies gives estimated annual losses of N as < 0.1 kg/ha/yr. Since P is strongly adsorbed by soil particles, losses as sediment can be higher than in the dissolved form. However, losses are still typically small at < 0.2 kg/ha/yr.

In total, phosphorus is generally retained very effectively by most acid forest soils, and small losses are approximately balanced by atmospheric inputs. Nitrogen inputs are greater than outputs. Thus, N tends to accumulate in forest systems tied up in organic matter. Since inputs for N and P are equal to or greater than normal outputs, productivity declines should not occur unless harvest removals significantly reduce soil and forest floor reserves.

Estimated soil reserves of N and P for a typical sandhills soil are 3600 kg/ha of total N and 3.5 kg/ha of available P to a depth of 2 m. Because there is little iron and aluminum in these sandy soils, most of the P is contained in the soil organic matter. The N to P ratio for sandy soils is 10:0.2 - 0.4, giving an estimate of 72 to 108 kg/ha for total P. Total P can alternatively be estimated by assuming that about 3 percent of the soil organic matter cycles each year to maintain the 3.5 kg/ha of available P, which gives an estimate total P of 117 kg/ha. The estimated N and P on the forest floor is 75 kg/ha of N and 7 kg/ha of P at age 10; 108 kg/ha of N and 9 kg/ha of P at age 20. These were estimated using data for other southern pines. Although there may be some differences due to species, the soil and climate are very similar and the data should be quite close.

Based on the estimates derived by the above process, depletion of N reserves should not be a problem for sand pine sites. Even under short rotations of 12 years with a density of 6640 trees/ha and total aboveground chipping, the soil reserves and inputs are such that after 20+ rotations reserves would still be about 1000 kg/ha. Assuming a turnover of 3 percent per year, 30 kg/ha is available for use which should be adequate for the estimated demand of about 26 kg/ha/yr.

A very different situation exists for phosphorus. There are few P-containing minerals in the soil to weather, and P inputs are small and balanced by outputs. So soil reserves must essentially supply the needed P. The reserves of P in the soil are significantly smaller (about 100 kg/ha) than N reserves. Total tree chipping at age 12 years would remove about 22 kg/ha of P. If both the 10- and 25-year harvest were by this method, 40 kg/ha would be removed under the other management system. Thus, it appears that all systems using total tree harvesting could cause a decline in productivity after only two to four rotations on sandhill sites. It would likely take more rotations than the data indicate because even with full-tree chipping a significant portion of the tree crowns, and therefore nutrients, 20 to 40 percent, are left on the site. In addition, the estimates of reserves and removals may be incorrect. If the reserves were underestimated by 50 percent and removal overestimated by this amount, system one would have sufficient P for 15 rotations and system two for five rotations. However, a decline in productivity should still occur with total tree harvesting, although not as quickly.

Based on the above estimates of reserves and potential removals of P under different harvesting systems, to avoid a long-term reduction in site productivity only the stem portion of sand pine trees should be utilized. The crown material, especially needles, is more valuable for organic matter and nutrients than it is as a raw material for wood, paper products, or fuel. This does not preclude the use of sand pine plantations for biomass or fuelwood production, but because only the stem should be harvested it would make sand pine less competitive with other species which normally grow on better sites.